3-1.Remember !! Heavy oil spilled from the wrecked Russian tanker "Nakhodka" attacked the coasts of Hokuriku district in 1997

OIL POLLUTION

Remember !!
Heavy oil spilled from the wrecked Russian tanker "*Nakhodka*" attacked the coasts of Hokuriku district in 1997

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INTRODUCTION

The *Nakhodka*, a Russian tanker loaded with C-typed heavy oil of 19,000 kl was divided into sections and submerged off Oki Island, Shimane Prefecture on January 2, 1997. The bow, after being drifting for 4 days, was wrecked off Anto, Mikuni Town, Fukui Prefecture, threatened throughout the various shores of Ishikawa Prefecture geographically as well. A serious heavy oil spill situation of the wrecked bow in Ishikawa Prefecture is shown in Figure 1. Shores damaged by oil washing, drifting oil in mass and oil slicks were observed by helicopter of aerial research of K. Tazaki, on February 8, 1997. An oil layer at the shore of Mikuni Town reached over 50 cm in thickness. Stormy weather continued to hamper cleanup efforts for the volunteer and the officials to remove oil from the shore and coastal water. Clean up of beach daubed with spilled oil is serious and hard problem to dissolve. We conducted field surveys in order to examine the conditions of heavy oil washing ashore on the Ishikawa coastline. The impacts of oil slicks to the marine environment and water pollution were studied. This incident caused by heavy oil spill of 6,200 kl yielded serious environmental problems throughout the shores of Hokuriku District. The 400 km of beach had to be cleaned manually. Our laboratory at Kanazawa University concentrated the attention on this environmental problem, and conducted a series of environmental researches (Tazaki et al. 1997). The latest and simple method to rinse the polluted beach sands and gravels was by using the warm seawater where this method could remove oils from beach materials effectively. In this paper, some results of the researches are introduced, including the actual situation of "bioremediation".

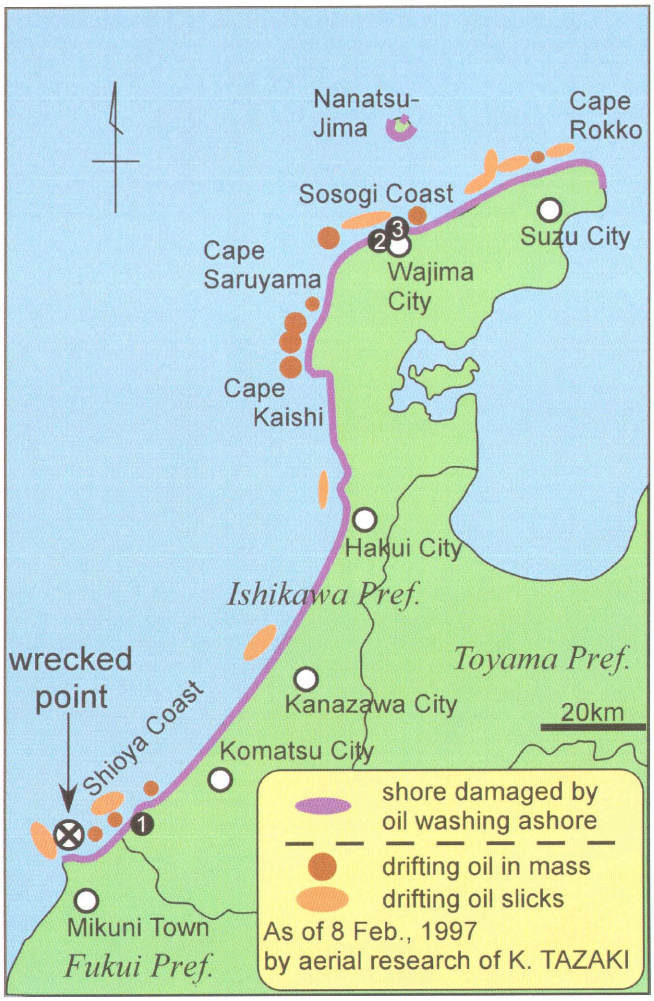

Figure 1 Map of the contamination area where are heavy oil spill from Russian tanker *Nakhodka* in January, 1997 covered ashore from Mikuni, Fukui Prefecture, to Noto Peninsular, Ishikawa Prefecture. 1 ; Shioya sandy beach, 2 ; Osawa inlet, 3 ; Atake beach.

SITUATION OF OIL CONTAMINATIONS

Popular beaches and bays, such as Mikuni rocky seashore (left), Shioya sandy beach (right) (Figure 2), Osawa inlet (Figure 3) and Atake graveled beach (Figure 4), were covered with viscous heavy oil on January 9 - 10, 1997. Continuously, more oil washed ashore, driven by northwest strong wind and flood tide on February and March. It was almost endless to cleanup the costal areas. The oil in mass damaged the famed rocky coastline of Noto peninsula, Quasi-National Park where is 50 m below from a traffic road. Numerous spotted oil slicks were recognized even one month later from the incident. Nanatsu-jima, northern Noto peninsula, designated as a national wildlife protection area of seabird conservations was threatened by oil spill as well. The volunteer and the officials tried to cleanup the coastal lines mostly by hands and buckets.

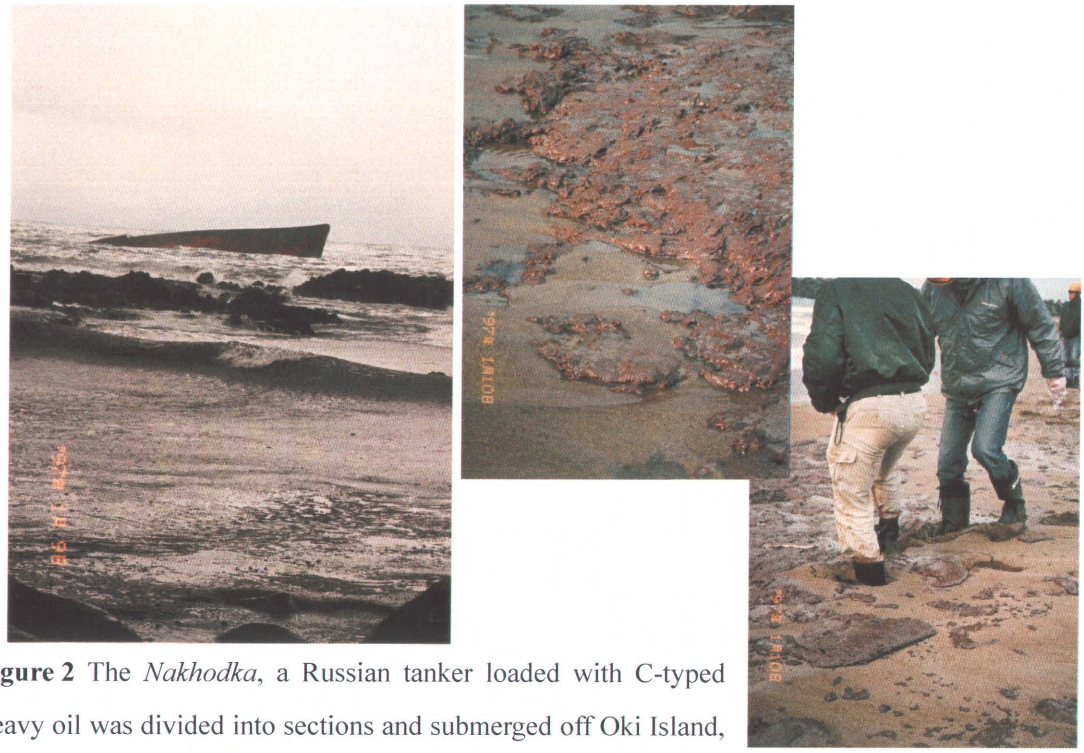

Figure 2 The *Nakhodka*, a Russian tanker loaded with C-typed heavy oil was divided into sections and submerged off Oki Island, Shimane Prefecture on January 2, 1997. The bow, after drifting for 4 days, was wrecked off Anto, Fukui Prefecture (left). The beaches were covered with viscous heavy oil 50 cm in depth. Everyday, more oil washed ashore, driven by northwest strong wind and flood tide at Shioya sandy beach (middle and right). Feet are buried under beach sands with oil 50 cm in depth.

Figure 3 Osawa inlet is the strongest wind site in Wajima, therefore northwest strong wind carried viscous heavy oil, to not only inlet (left) but also alongside of the quay (right). Note that the thick oil mats containing seaweeds more than 10 cm in thick. It was very heavy oily mats.

Figure 4 Atake beach in Wajima used to be one of beautiful gravel beach was covered with brown viscous heavy oil. We tried to cleanup each of the gravels one by one with cloth and hand, but it was beyond man's power. Finaly local residents have treated by mountain soils, to cover with it on the gravel beach.

Conditions of emulsified oil were rapidly changed within a few days. It was found through field examinations, heavy oil in mass was viscous in 1 - 2 days, and the color of oil turned from black to dark brown, and then to light with the growth of viscosity. Laboratory examinations recognized the "emulsified" phenomenon of heavy oil, and showed clearly that the specific gravity of heavy oil washing ashore (1.01 g/cm^3) was higher than the one of normal heavy oil (0.93 - 0.97 g/cm^3). Optical microscopic observation of emulsified heavy oil has showed that numerous bacteria inhabit in the oil. Fluorescence microscopic observation of emulsified oil clearly showed the distinction between oil and bacteria (Figure 5). The process that emulsified oil was decomposed by the exposure of ultraviolet rays was also observed. SEM-EDX analyses of C-typed heavy oil showed the normal oil is almost composed of carbon hydride, and contains several percent of sulfur (Figure 6A). The oil samples were collected from Anto, Mikuni on January 1997, and identified to have already been emulsified by seawater (Figure 6B).

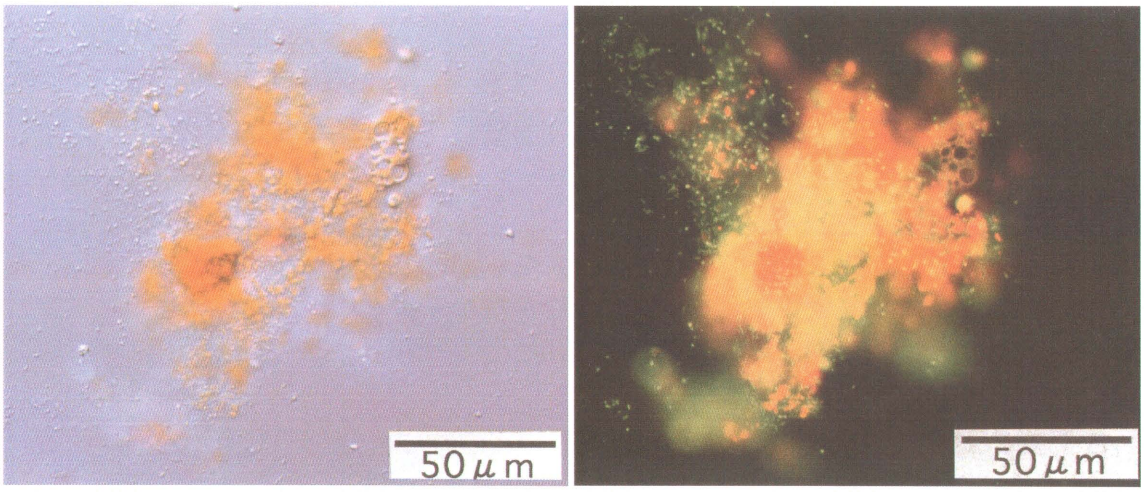

Figure 5 Optical microscopic observation of emulsified heavy oil in brown color showed that numerous bacteria in white inhabit in the oil (upper). Fluorescence microscopic observation (lower image) of emulsified oil clearly distinguished between oil in yellow and bacteria in greenish blue.

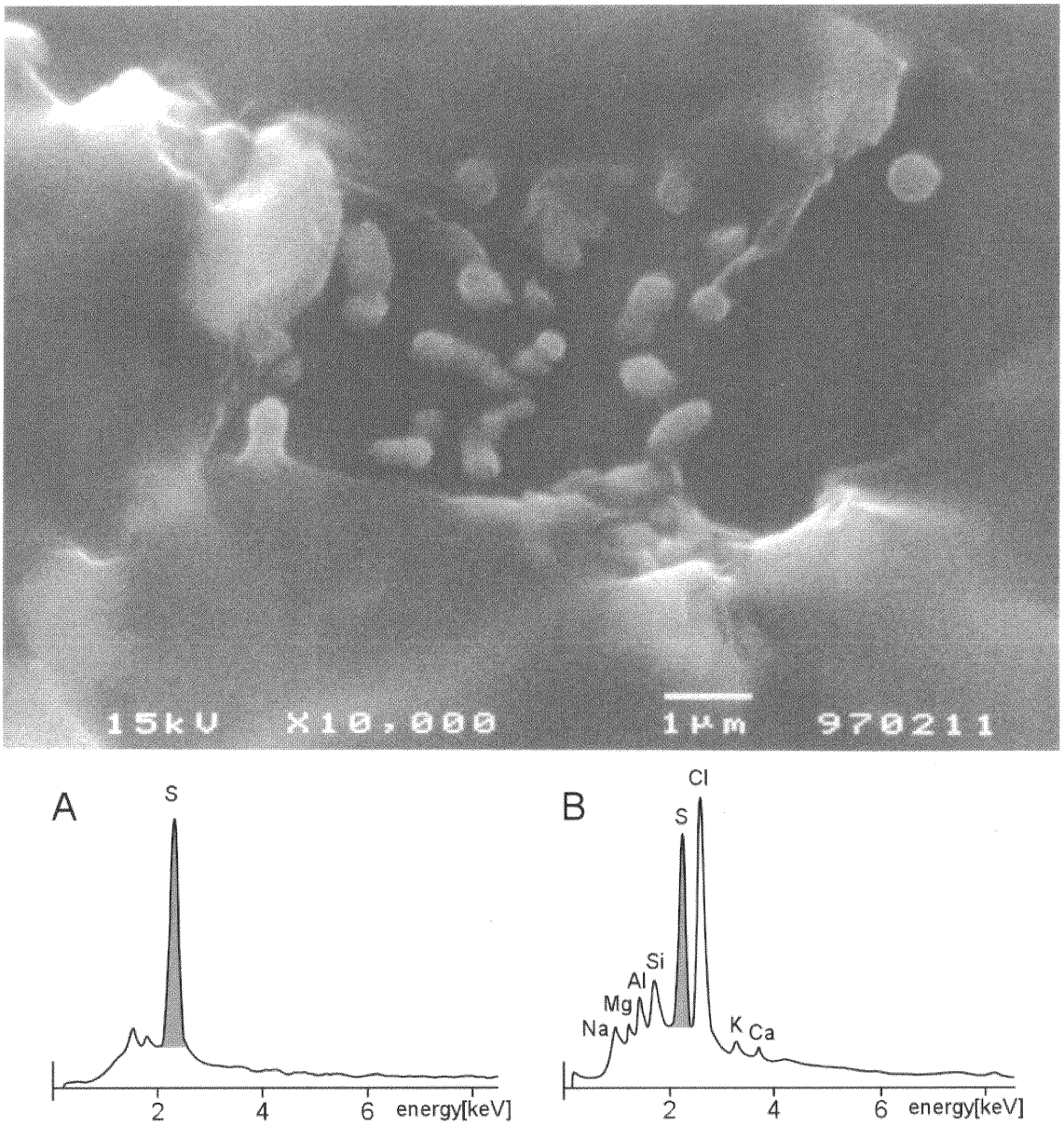

Figure 6 Scanning electron micrograph and energy dispersive analyses of C-typed heavy oil (A) and hydrocarbon-degrading microbes (B), after oil spill at Anto, Mikuni Town, Fukui Prefecture, on January 10, 1997. Normal oil is almost composed of carbon hydride associated with a sulfur of several percent. The EDX pattern of "B" identified to have already been emulsified by seawater, because Na and Cl contents were high.

DEGRADATION OF OIL

In this accident, remarkable microbial remediation research had been advanced. We really didn't have such experiences with this. In fact, hydrocarbon-degrading microbes were found in each polluted area of the near-shore environments. K. Tazaki supplied the same samples of spilled oil and the direct drawn oil from the *Nakhodka*, to other scientists. One of them, such as M. Ishiyama (Toyama University) carried out on his degradation research works. Ishiyama et al. (1999) isolated two bacterial groups, ODB-G1 and ODB-G2, from the spilled oil from the tanker. ODB-G1 contained two genera. One was classified as *Caulobacter* sp. on the basis of its morphogenesis during the cell cycle, and the other was classified as an *Alcanivorax* sp. based on the sequence of its 16S rRNA gene. ODB-G2 also contained two bacterial genera, *Alcanivorax* sp. and *Halomonas* sp., as identified by the BiOLOG carbon substrate utilization profile. All of these bacteria were gram-negative. The results obtained by the TLC/FID method showed that the both bacterial groups degraded the saturate fraction and the aromatic fraction very well. They were also able to degrade the resin fraction and the asphaltene fraction, although their degradation rate was relatively low.

Besides that, scanning electron micrographs of hydrocarbon-utilizing bacteria isolated from coastal areas. Heavy oil samples were collected from *Nakhodka* Russian oil tanker (A), Katano seashore (B), Atake seashore (C) and Osawa seashore (D) after 5 years of spilled accident (Figure 7) showing different species. The bacterial micrographs suggest us that the local degrader bacteria inhabited everywhere with many kinds of species. Each species carries a role to resolve heavy oil under the local conditions. That is a key to understand the sustainable "bioremediation" for polluted local area. After 5 years of spilled accident, degrader bacteria were still alive to keep the activity. Microbial degradation is the conversion processes dissolved and dispersed hydrocarbons into oxidized products by microorganisms. It is the fine and lasting processes, known as bioremediation, which has received wide attention, notably after the *Exxon Valdez* accident.

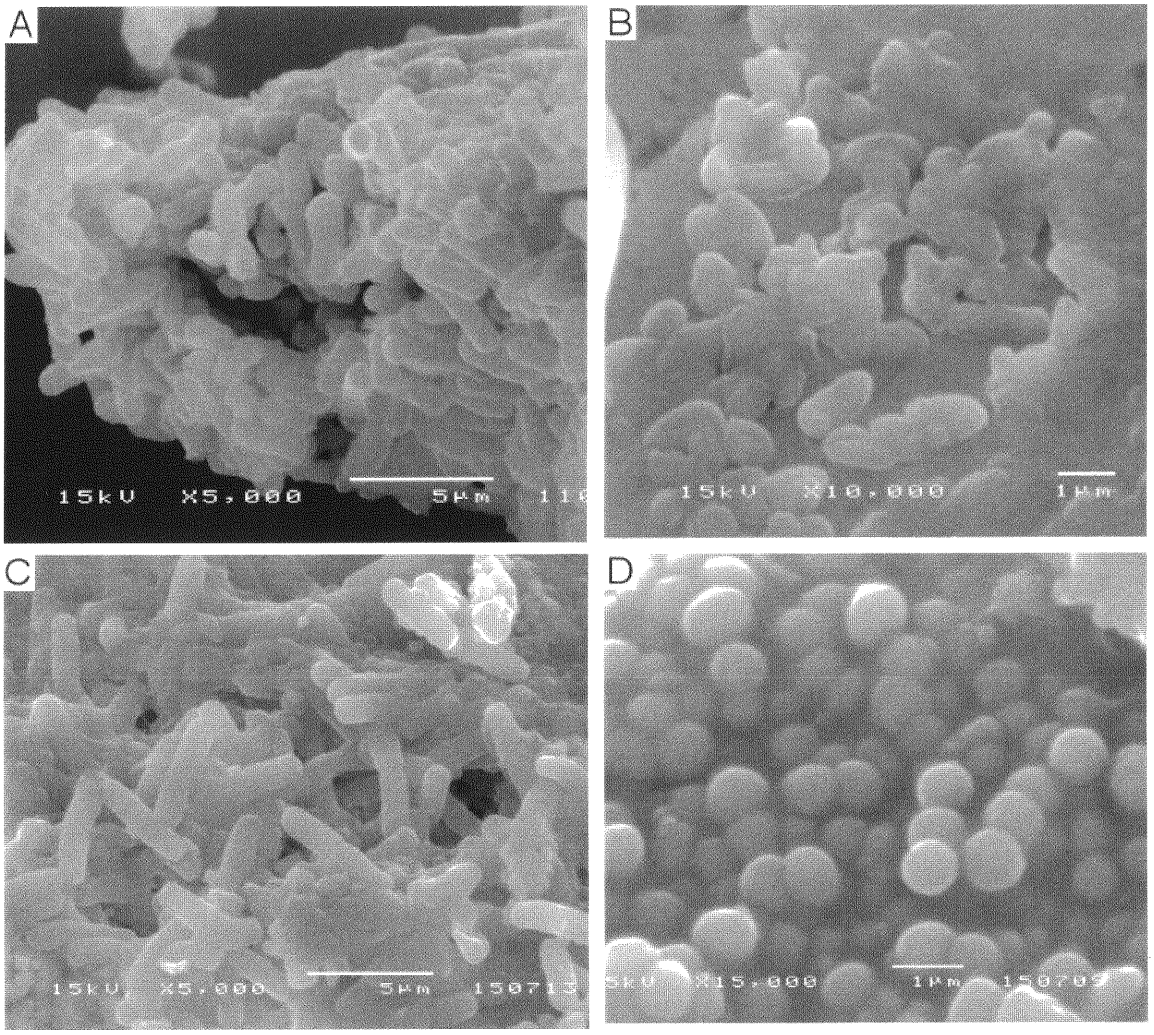

Figure 7 Scanning electron micrographs of hydrocarbon-utilizing bacteria isolated from coastal areas in the Sea of Japan because of *Nakhodka* oil spill. (A) Bacterial strain isolated from heavy oil sample collected from *Nakhodka* Russian oil tanker on 9 January 1997, (B) Bacterial strain isolated heavy oil-polluted sand samples collected from Katano seashore, Fukui Prefecture on 10 December 1999, (C) Bacterial strain isolated from heavy oil-polluted sand samples collected from Atake seashore, Ishikawa Prefecture on 21 November 2001, (D) Bacterial strain isolated from heavy oil samples collected from Osawa seashore, Ishikawa Prefecture on 21 November 2001.

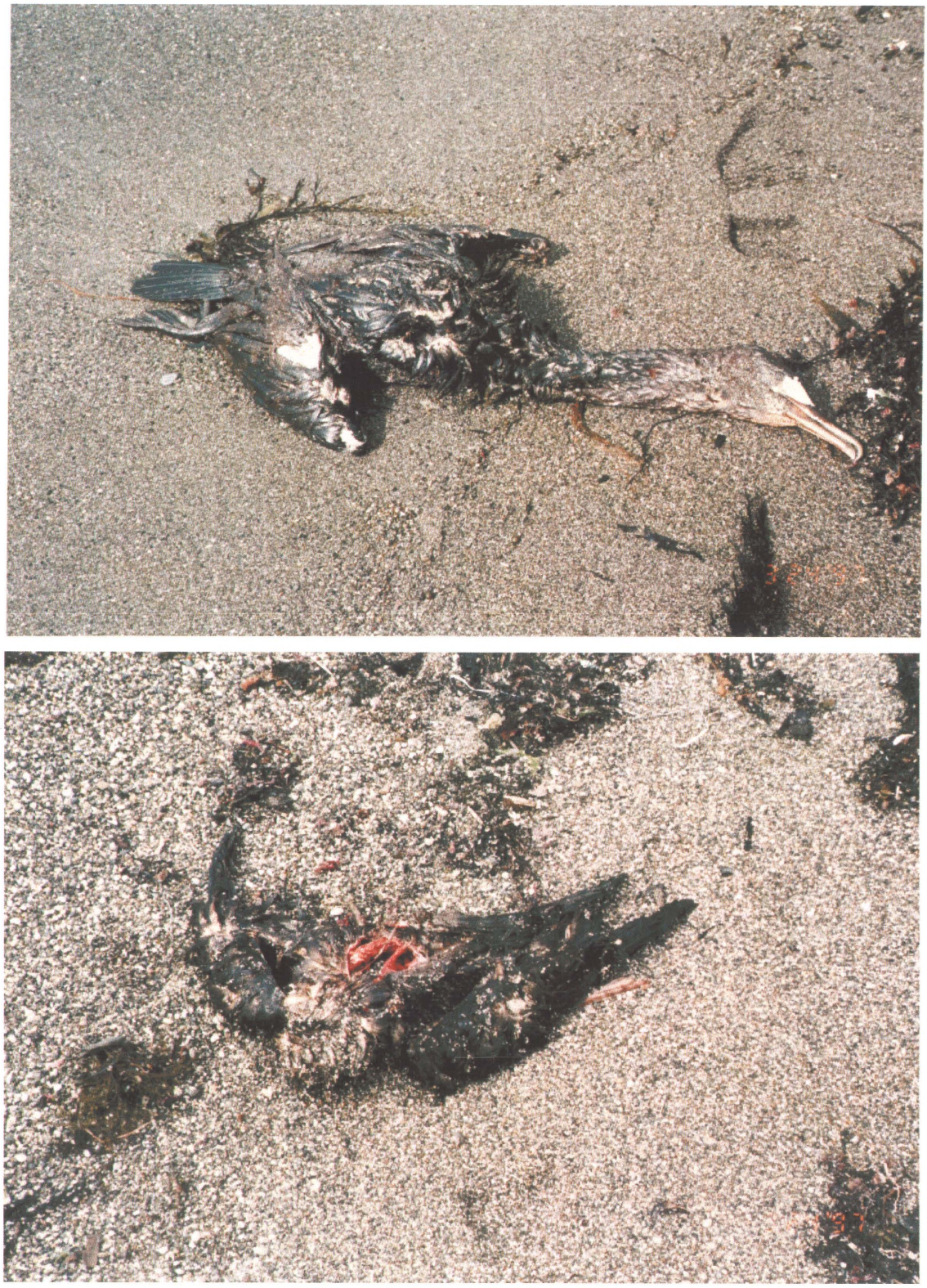

Figure 8 Harmed seabirds were found everywhere on ashore line at Noto Peninsula. Not only the oil cling to the feather of a seabird, but also some of seabirds were full of oil in the viscera.

DAMAGE OF WILDLIFE

We could figure out what sort of oil they were dealing to the other life. What was happened and how it was harmed seabirds shown in Figure 8. Since on January 1997, it slapped on seabird's lives in the water along 400 km of spoiled coastline. The spilled oil had the devastating effects on about 20 species of endangered birds in the winter along the coast. The data showed a substantial impact on seabirds, reported by Ishikawa Zoo. The 615 seabirds had withdrawn from the coast in Ishikawa Prefecture, including 264 living birds. After taking care of birds and rehabilitation by volunteer activity, only 56 seabirds were recovered. Totally 1311 seabirds had been withdrawn in the Sea of Japan.

A marine conservation biologist at the University of Alask, Fairbanks, who studied the 1989 *Exxon Valdez* oil spill, says that to believe the sunken oil will remain stable is "more wishful thinking than reasoned expectation." If the oil containers break, much of it could still reach the surface. Delayed effects from the *Exxon Valdez* oil spill included genetic damage in wildlife, adding that more than 13 years after that spill, only a quarter of the injured populations was fully recovered (Bohannon et al. 2002). Therefore we have to keep a very close watch on *Nakhodka* spill what is happening the oil in mass damaged the famed rocky, gravel and sandy coastlines of Noto Peninsula. We, scientists, must remember the tragic accident for our future environment of Hokuriku district.

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